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Dependence of CCFL Characteristics on Ambient Temperatures

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Abstract

The electrical and optical characteristics of the cold cathode fluorescent lamps (CCFL) were measured and investigated under the wide ambient temperatures ranging from –30 °C up to +100 °C. The highest luminous efficiency of the CCFL of 55 lm/W was obtained at the ambient temperature of 50 °C.

1. Introduction

The CCFLs in production contain mercury because the excited mercury vapor radiates efficient ultra violet light which excite the phosphors of the CCFL so that the visible light is generated from the phosphor coated in the inner surface of the CCFL tubes [1]. The mercury vapor pressure within CCFL varies according to the ambient temperature of the CCFL so that the electrical and optical characteristics of the CCFL varies according to the ambient temperature. The mercury contained in the tube is almost in the liquid state at +20°C. At this temperature, very small amount of mercury is vaporized [2,3]. The mercury vapor pressure of the CCFL varies according to the ambient temperature of the CCFL so that the electrical and optical characteristics of the CCFL vary under the various ambient temperature. Therefore, there are some limitations in the application of CCFLs because the characteristics of the CCFL depends largely on the ambient temperature [4,5].

This paper describes the characteristics of CCFLs that have been used as a backlight for liquid crystal displays (LCD) and the other various purposes, including the effect of the temperature on the electrical and optical characteristics of the CCFL in operation. This investigation furnishes experimental data on the thermal dependence of CCFL characteristics.

2. Experimental

The electrical and optical characteristics of CCFLs were measured and investigated under the wide ambient temperatures ranging from –30 °C up to +100 °C. Inner diameter of the CCFL under investigation was 2.0 mm and outer diameter was 2.6 mm. Length of the tube was 300mm. The inverter used for driving CCFL had sinusoidal output with its ambient frequency of 40kHz.

The lamp current, voltage and luminance were measured and then the luminous efficiency of CCFL determined as a function of temperature. A varied vapor pressure of mercury affects the sustaining voltage. So the sustaining voltage was measured at the same time. The variation of the sustaining voltage was analyzed through the Paschen's law.

The CCFL under test was placed in the constant temperature chamber to be operated under various temperatures from –30°C to +100°C. Fig. 1 shows the process of measuring the electrical and optical characteristics of CCFL under test.

Power consumption and luminance obtained through the measurement process were used to determine the luminous efficiency of CCFL. The luminous efficiency, η, can be expressed as in (1).

$$\eta = (\pi \cdot \text{Lum.} \cdot S) / P_{fl} \ [\text{lm/W}] \qquad (1)$$

where, η , Lum. , S and P_{fl} represent the luminous efficiency, luminance, emissive area and power consumption in the CCFL, respectively.

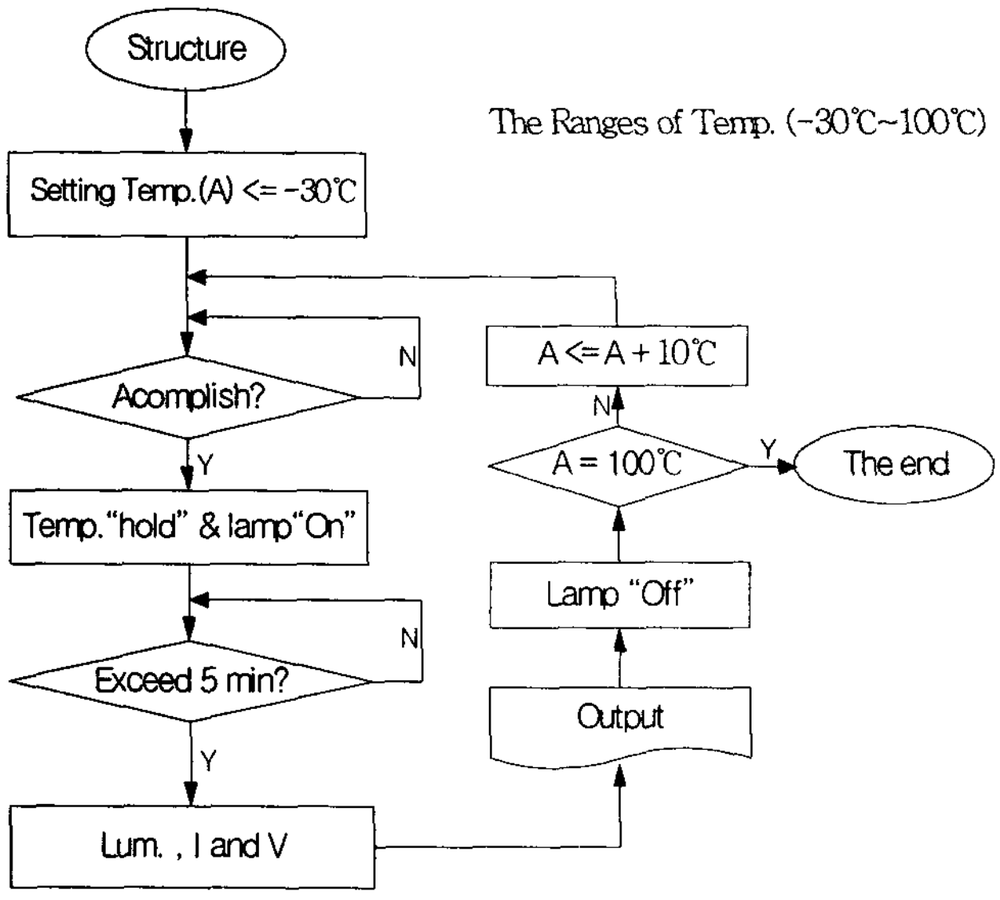

Fig. 1. The flow chart for the measurement of CCFL characteristics under various temperatures.

3. Results and discussion

The various characteristics of CCFL were measured according to the variation of the ambient temperatures. Especially, the luminance of the CCFL was measured under the wide ambient temperatures. The current and the voltage characteristics were measured. The measured data were used to determine the luminous efficiency of CCFL.

The measurement results showed that the luminance of the CCFL ambient under the temperatures of –30 ℃, 20 ℃, 60 ℃, and 100 ℃ were 560 cd/m^2, 7,060 cd/m^2, 34,800 cd/m^2 and 23,300 cd/m^2, respectively, as shown in Fig. 2.

The change of luminance of the CCFL is deeply related with the sustaining voltage as the temperature varies. The sustaining voltages varied according to the variation of the ambient temperatures. The sustaining voltages measured at 20℃, 50℃, and 100℃ were 579V_{rms}, 392V_{rms}, and 432V_{rms}, respectively. The lowest sustaining voltage of 392V_{rms} was measured under the ambient temperature of 50℃ as shown in Fig. 2. The luminance and sustaining voltage varied in an opposite manner. Fig. 2 shows how sustaining voltage sensitively reacts in relation to the varied temperature. The mercury vapor pressure within CCFL varies according to the temperature, which in turn, changes the sustaining voltage of the CCFL.

The highest luminous efficiency of the CCFL of 55 lm/W was obtained at the ambient temperature of 50 ℃, as shown in Fig. 3. Luminous efficiency at the high temperature range is relatively higher than luminous efficiency at the low temperature range. It was shown that the luminance of the CCFL at low temperature range is so small that it seems very difficult to use the CCFLs for high brightness application at very low temperature ranges.

4. Conclusion

It is found by experiment that the electrical and optical characteristics of the CCFL is highly dependent on the ambient temperature. The variation of mercury vapor pressure affects the electrical and optical characteristics of CCFLs. The highest luminous efficiency of the CCFL of 55 lm/W was obtained at the ambient temperature of 50 ℃. Normal operating characteristics of the CCFLs cannot be obtained at the ambient temperature below 20℃. Particularly, it is almost impossible to get a normal optical characteristic under the ambient temperature below 0℃. More research is needed to find a way of increasing luminance of the CCFL for the applications at low ambient temperature operation .

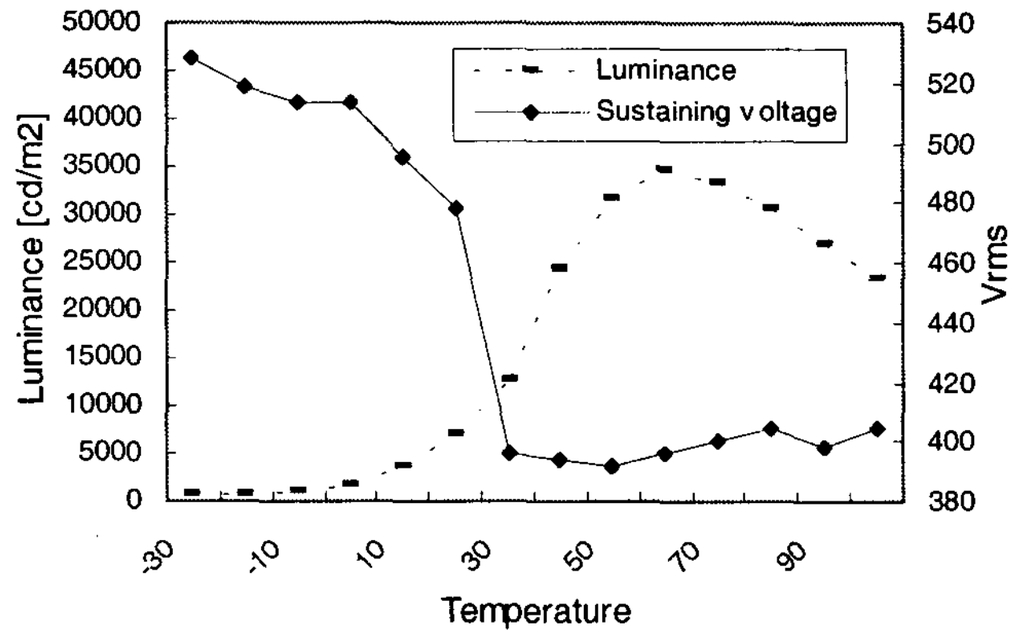

Fig. 2. Trend of the variation of luminance and sustaining voltage as the operating temperature varies.

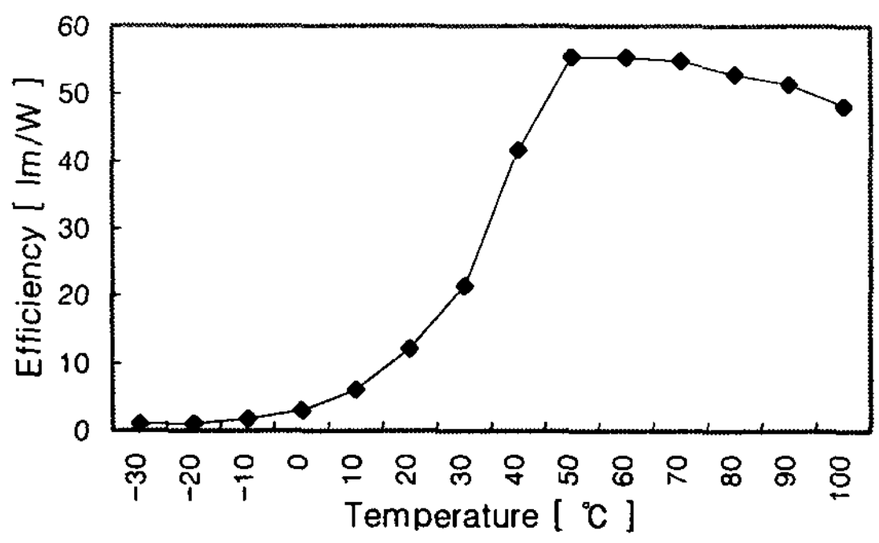

Fig. 3. Luminous efficiency of the CCFL at various temperatures.

5. References

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